Asymmetric Effects of Exchange Rate Changes on British Bilateral Trade Balances

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Abstract

This research presents first empirical time series evidence of the asymmetric impact of exchange rate changes on Britain's trade balances with her 8 trading partners. Recent advances in time series and cointegration analysis have allowed for the estimation of the nonlinear effects of currency depreciations on countries' trade balances. To this extent, we employ the nonlinear version of the Autoregressive Distributed Lag (ARDL) approach to cointegration and error correction methodologies to examine whether pound appreciations affect trade differently than do pound depreciations. We use monthly trade data which runs from 1998M1 to 2015M11 to capture more robustly the asymmetric impacts of exchange rate changes on trade balances. Econometric results from the non-ARDL procedures reveal that there exist long-run relationships in the case of UK-Canada, UK-Germany, UK-Italy, UK-Japan, UK-Korea, and UK-US trade balance models. Nevertheless, we did not find any long-run relationship in the case of UK-Spain and UK-Norway trade balance models. We also present empirical evidence for the existence of long-run asymmetries of exchange rates in the case of UK-Germany, UK-Italy, UK-Korea, and UK-Japan trade balance models. This paper also discusses policy implications of the empirical results as well as offering policy recommendations.

Keywords: International trade, Exchange rates, Asymmetry, Nonlinear Cointegration.
JEL Classifications: F14, C22

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I. Introduction

The impact of exchange rate changes on the level of trade balance is one of the unresolved major issues in international economics. This issue has been conceptualized using J-curve which states that currency devaluations lead to decrease in a country's trade balance in the short-run before the expected improvement in the long-run. It is observed that initial reductions in exports are due to some rigidities such as fixed trade contracts. The theoretical concept of J-curve was initially introduced by Mageee (1973) but it was empirically tested first time by Bahmani-Oskooee (1985). The empirical model of Bahmani-Oskoee suggests that due to lag structure on exchange rates, depreciation worsens in the short-run the trade balance and then improves it in the long-run. Thus, the exchange rate changes have crucial impact on a country's international competitiveness. Later on study of Rose and Yellen (1989) demonstrated a statistical definition of a "J-curve" which requires the coefficients of exchange rates to be negative and statistically insignificant in the short-run and to be positive and statistically significant in the long-run. Since the latter study, the empirical research on J-curve has been growing significantly year by year. A recent comprehensive study of Bahmani-Oskooee and Hegerty (2010) presents systematic breakdown of these studies.

Previous empirical studies on attempting to measure the existence of J-curve hypothesis assumes a linear relationship between the variables. On using the nonlinear ARDL approach to cointegration of Shin *et al*. (2014), this assumption has been questioned empirically by recent studies of Bahmani-Oskooee and Fariditivana (2015), Bahmani-Oskooee, *et al*. (2016), Bahmani-Oskooee and Halicioglu (2016). The new econometric methodology permits positive and negative changes in a variable and presents evidence of symmetric affects only if these two affects have the same sign and are of the same magnitude. In other words, with this new econometric approach we are able to identify whether the effects of exchange rate changes are symmetric or asymmetric.

In this study, we test whether real depreciation of British pound has improved her trade balance with her eight major trading partners. To this extent, Section II of this study provides a brief empirical literature review on British trade balance. Section III explains the models and econometric methodology. Section IV is related to econometric results and interpretations. Section V is reserved for concluding remarks. Finally, Appendix cites data sources and definition of variables.

II. A Brief Literature Review

The impact of exchange rate changes on trade balances was initially tested using the Marshall-Lerner condition which is based on the price elasticities of import and export demands. If the sums of these elasticities exceed unity, it leads to a conclusion that depreciation of a currency will improve the trade balance in the long-run. To this extend study of Houthakker and Magee (1969) provided a first empirical evidence for 26 developed and developing countries. As for the J-curve phenomenon in the case of the UK, there exist several empirical studies providing conflicting evidences. Miles (1979) estimated the impacts of devaluation for 14 developed and developing countries. The results indicated that a real depreciation of the British pound will worsen the UK trade balance and the balance of payments in the long-run. Using similar methodology, however, Himarrios (1989) contradicted the findings of Miles (1979). Rose (1991) relied upon cointegration technique of Engle-Granger (1987) and concluded that real depreciation is ineffective for improving the trade balance in the long-run. Bahmani-Oskooee and Alse (1994) also reached the same results in their studies. Boyd *et al*. (2001) is another study that using Johansen's cointegration (1988) methodology confirmed the results of Rose (1991). Rose and Yellen (1989) developed a new approach to test the impact of exchange rate changes on trade balance. They could not find any evidence of J-curve neither in the short-run nor in the long-run in the case of the UK trade balance. In a similar study, Bahmani-Oskooee and Brooks (1999) confirmed the study of

Rose and Yellen (1989). Using a different approach, Cushman (1987) concluded that dollar devaluation could have an adverse effect on the trade balance between the US and UK. Bahmani-Oskooee and Kovyryalova (2008) using the econometric methodology of Pesaran *et al*. (2001) and disaggregating the international trade of the UK examined the existence of J-curve in her 177 industries. They concluded the existence of J-curve in 66 industries.

The above studies related to the trade balance of the UK are based on the assumption that the impact of exchange rate on the trade balance is symmetric. In this study, we extend the literature by introducing the non-linear ARDL cointegration approach of Shin *et al*. (2014) for the UK's trade balance with her 8 partners and try to establish asymmetric effects of exchange rate changes.

III. The Models and Econometric Methods

The bilateral trade balance model adopted from the literature is as follows:

$$LnTB_{i,t} = a + b\ LnY_{UK,t}, + c\ LnY_{i,t} + d\ Ln\ REX_{i,t} + \varepsilon_t \qquad (1)$$

where TB_i is a measure of the trade balance between the United Kingdom and trading partner *i*. All variables are in natural logarithms. The trade balance is defined as the ratio of Britan's imports from trading partner *i* over its exports to trading partner *i*. In equation (1) there exist three explanatory variables: the level of income in the UK (Y_{UK}); trading partner's *i* income(Y_i), and the real bilateral exchange rate, REX between the UK and her trading partner. Thus, we expect an estimate of *b* to be positive and that of *c* to be negative. By way of construction, as shown in the Appendix, since a decline in REX signifies depreciation of the British pound, if it is to improve the trade balance we expect an estimate of *d* to be positive.

Equation (1) is converted to an error-correction model so that we can also assess the short-run effects of exchange rate changes, hence the J-curve effect. To this extend, We adopt Pesaran *et al.*'s (2001) bounds testing, or ARDL approach as follows:

$$\begin{aligned}\Delta LnTB_{i,t} = \quad & a' + \sum_{k=1}^{n} b_k' \,\Delta\, Ln\, TB_{i,t-k} + \sum_{k=0}^{n} c'_k \,\Delta\, Ln\, Y_{UK,K} + \sum_{k=0}^{n} d'_k \,\Delta\, Ln\, Y_{i,t-k} \\ & + \sum_{k=0}^{n} e'_k \,\Delta\, Ln\, REX_{i,t-k} + \lambda_1 Ln\, TB_{i,t-1} + \lambda_2 Ln\, Y_{UK,t-1} \\ & + \lambda_3 Ln\, Y_{i,t-1} + \lambda_4 Ln\ REX_{i,t-1} + \mu_t \qquad (2)\end{aligned}$$

Equation (2), set up as such that short-run effects are inferred by the estimates of coefficients attached to first-differenced variables and the long-run effects are derived by the estimates of $\lambda_2 - \lambda_4$, normalized on λ_1.[1] However, to validate the long-run effects, cointegration must be established. This is done by applying the familiar F test with new critical values tabulated by Pesaran *et al* (2001). The integrating properties of the variables should require variables in a combination of $I(0)$ and $I(1)$, which are properties of almost all macro variables. Traditional definition (Magee 1973) of the J-curve requires for negative estimates of e'_k at lower lags, followed by positive values at higher lags. As for the definition of Rose and Yellen (1989) J-curve, it is required negative or insignificant short-run estimates of *e*'s, combined with significantly positive normalized estimates of λ_4.

Studies of Bahmani-Oskooee and Fariditavana (2015 and 2016) presents another dimention of the J-curve interpretation. They argue that that the estimate of λ_4 is found to be insignificant. This could be due to assuming that the exchange rate has symmetric effects. Therefore, depreciations should be separeted from appreciations. Once depreciations are separated from appreciations, it is possible for depreciations to have significant effects on the trade balance and appreciations to have insignificant effects. Such asymmetric effects could be due to a change in a trader's expectations concerning exchange rate changes. In order to implement the third way of J-curve interpretation, the real exchange rate *LnREX* is

[1] For the precise normalization procedure, see Bahmani-Oskooee and Fariditavana (2015).

decomposed into its positive and negative changes using the concept of partial sums as follows:

$$POS_t = \sum_{j=1}^{t} \Delta LnREX_j^+ = \sum_{j=1}^{t} \max(\Delta LnREX_j, 0),$$
$$NEG_t = \sum_{j=1}^{t} \Delta LnREX_j^- = \sum_{j=1}^{t} \min(\Delta LnREX_j, 0) \qquad (3)$$

In this setting POS, which represent the partial sum of positive changes and currency appreciation; NEG which stands for the partial sum of negative changes and currency depreciation. The new variables created in equation (3) and replace *LnREX* in eqution (2), thus in this new set up we have equation (3) as follows:

$$\Delta LnTB_{i,t} = a' + \sum_{k=1}^{n1} b'_k \, \Delta LnTB_{i,t-k} + \sum_{k=0}^{n2} c'_k \, \Delta LnY_{UK,t-k} + \sum_{k=0}^{n3} d'_k \Delta LnY_{i,t-k}$$
$$+ \sum_{k=0}^{n4} e'_k \Delta POS_{t-k} + \sum_{k=0}^{n5} f'_k \, \Delta NEG_{t-k} + \theta_0 LnTB_{i,t-1} + \theta_1 LnY_{UK,t-1}$$
$$+ \theta_2 LnY_{i,t-1} + \theta_3 POS_{t-1} + \theta_4 NEG_{t-1} + \xi_t \qquad (4)$$

Equation (3) represents the approach of Shin *et al.* (2014) which demonstrate that all statistical procedures that are applied to estimate error-correction model (2) are equally applicable to model (4). By the way of construction of POS and NEG variables, Equation (4) is called as a nonlinear ARDL model, whereas model (2) is labeled as a linear ARDL model. Studies of Bahmani-Oskooee and Fariditavana (2015 and 2016)[2,3] suggest that once equation (4) is estimated, short-run asymmetry is judged by comparing estimates of *e*'s to estimates of *f*'s, and long-run asymmetry is judged by comparing the normalized estimate of θ_3 to the normalized estimate of θ_4. Providing that estimates of *e*'s or *f*'s are negative or insignificant,

[2] For other applications of the partial sum concept see Apergis and Miller (2006) on the effects of the U.S. stock market on consumption; Delatte and Lopez-Villavicencio (2012) on exchange rate pass-through, Verheyen (2013) on interest rate pass-through mechanism to deposit rates; and Bahmani-Oskooee and Friditavana (2015) on testing the S-curve.

[3] Note that, as argued by Bahmani-Oskooee and Fariditavana (2016), the expected sign of the normalized coefficient estimates of POS and NEG variables in model (4) are the same as that of REX in model (2).

but the estimate of normalized θ_3 or normalized θ_4 are significantly positive, this result should also be intepreted present a way of support for the J-Curve.

IV. Results

Linear ARDL[4] model (2) and the nonlinear ARDL model (4) between the United Kingdom and each of its 8 trading partners are estimated. Monthly data over the period 1988M1-2015M11 are used to carry out the estimations. The Appendix provides data sources and definitions of variables as well as exceptions of the study period for two partners. The list of partners and their share of British trade inside the parentheses are: Canada (1.56 %), Germany (15.24%), Italy (3.62%), Japan (1.58%), Korea (1.19%), Norway (2.12%), Spain (3.41%), the U.S. (12.56%).[5]

Each model was estimated by imposing a maximum of eight lags on each first-differenced variable and by using Akaike's Information Criterion (AIC) to select the optimal lags. The results of each optimal model are presented in Tables 1-8. Each table consists of two separate parts. Part I reports the results for the linear ARDL model (2) and Part II reveals the results for the nonlinear model (4). Moreover, each panel is divided into three further parts. Panel A and D report the short-run coefficient estimates respectively, Panel B and E reports the long-run normalized estimates, respectively. Diagnostic statistics are reported in Panel C and F, repectively[6].

Tables 1-8 go about here

Due to large number of information in each table, we will first concentrate on Table 8 which demonstrates the results of the UK and US bilateral trade models. It is hoped that this approach will make it easy to summarize the results for the remaining 7 partners. From Panel

[4] For some other applications of this method see Tang (2007), Halicioglu (2007), Halicioglu (2008a and 2008b) Wong and Tang (2008), De Vita and Kyaw (2008), Dell'Anno and Halicioglu (2010), Chen and Chen (2012), Wong (2013), and Tayebi and Yazdani (2014).

[5] The trade shares belong to November of 2015, our last period and are calculated as sum of each partner's exports and imports as a percent of British total exports to and imports from the world.

[6] All variables are tested for stationarity tests and none of them is beyond $I(1)$.

A in Table 1, it is noted that all variables except the income of the UK carry at least one significant coefficient, along with the real bilateral exchange rate, all have short-run significant effects on the trade balance between the two countries. As for the long-run results, it seems that two of the normalized long-run coefficients are significant. For the existence of co-integration, it is required that at least one of the coefficients were significant, the F statistic reported in Panel C shows that variables are co-integrated, since our reported statistic is greater than its upper bound critical value of 4.35.[7] The speed of convercenge between the variablesis judged by the error-correction term, denoted by ECM. It is obtained from the linear combination of lagged level variables in (2) by ECM_{t-1}, and estimate this new specification after imposing the same optimum lags from Panel A. A significantly negative coefficient obtained for ECM_{t-1} will support adjustment toward the long-run, and the size of the estimated coefficient in absolute value measures the adjustment speed. Furthermore, this is an alternative method of supporting co-integration in case the F statistic was insignificant, according to Banerjee *et al* (1998). In our model, the absolute critical value of 3.82 obtained from Benarjee *et al*. (1998) less than the t-ratio (4.18) of the estimated coefficient which confirms adjustment of the variables in a linear manner.[8]

Diagnostic and additional statistics of the econometric models are in Panel C. Since there are lagged values of the dependent variable in the model, the best way of testing for serial correlation among the residuals is the use of the Lagrange Multiplier (LM) statistic. It has a χ^2 distribution with four degrees of freedom. Another statistic we report is the Ramsey's RESET statistic, which is used to test misspecification of the optimal model. This statistic is also distributed as χ^2, but with only one degree of freedom. Short-run and long-run stability of the estimated coefficinets are judged by CUSUM (denoted by CUSM) and CUSUMSQ

[7] This critical value is at the usual 5% significance level when there are three exogenous variables. It comes from Pesaran *et al.* (2001, Table CI-Case III, p. 300). A comparable figure at the 10% level is -3.47. When there are four regressors, these critical values change to -4.03 and -3.67, respectively.

[8] Banerjee *et al*. (1998) demonstrate that the t-ratio for ECM_{t-1} is nonstandard; hence they tabulate the new critical values which depend on the number of regressors and number of observations.

(denoted by $CUSM^2$) tests of Brown *et al*. (1974) . Stable coefficients with "S" and unstable ones with "UNS" are denoted. As indicated in Panel C, all estimated coefficients are stable.[9] Finally, the adjusted R^2 is also reported to judge the strength of fit.

The short-run real bilateral real exchange rate is positive and statistically significant whereas the long-run real bilateral exchange rate is also positive and statistically significant. This result indiactes that non-existence of the J-curve as far as the Magee (1973) and Rose and Yellen (1989) approaches are concerned. Would the results be different if we estimated the trade balance model in non-linear way? In other words, if we decomposed the exchange rates in terms of appreciations and depreciations, could the results would alter? In order to obtain plausible answer for this question, the Panel II of Table 8 is utilized in which the results of the nonlinear ARDL model presented. In order to test the existence of asymmetry between the variables of POS and NEG, we concentrate on the coefficients of these variables. The size of ΔPOS and ΔNEG's coefficients is different. Therefore, at first glance, we may conclude that short-run effects of exchange rate changes are asymmetric. However, this result should be confirmed by a formal test. To this end, we implement short-run "asymmetry" by applying the Wald test to determine if the sum of the short-run coefficients associated with ΔPOS and ΔNEG variables are significantly different; i.e. if $\sum e' \neq \sum f'$ in the nonlinear model (4). If the Wald statistic is significant, then there is evidence of short-run asymmetry. This statistic is denoted by W_{Short}, reported in Part II-Panel F of Table 8, which has an insignificant value of 0.00004, supporting short-run symmetry. Moreover, in order to test long-run asymmetry, we apply the Wald test to determine if estimates of θ_3 equal θ_4 in the nonlinear model (4). Denoting this statistic with W_{Long}, our calculated Wald statistic of 1.10 in Table 8 is highly insignificant, supporting long-run symmetry.[10]

[9] For a graphical presentation of CUSUM and CUSUMSQ tests in this context see Bahmani-Oskooee and Fariditavana (2015).

[10] Note that the Wald statistic in both cases has a χ^2 distribution with one degree of freedom.

The results of long-run estimates of the nonlinear model appears to more meaningful in regards to diagnostic statistics .[11] The additional statistics show that ECM_{t-1} carries a highly significant coefficient, supporting fast adjustment towards the long-run. The estimated coefficients are stable both in the short-run and long-run. overall stability of the coefficients estimated coefficients seem to be stable. Overall, the nonlinear ARDL model performs better, by supporting co-integration among the variables. However, there is no asymmetric effects of exchange rate changes on the UK-US trade balance. As for the third definition of J-curve which is proposed by Bahmani-Oskooee and Fariditavana (2015 and 2016), it seems that this effect exists partially since the short-run coefficient of NEG is negative and statistically insignificant but its long-run coefficient is positive and statistically significant.

The analyses used above can be extended into other trading partners of the UK. However, for brevity, the results will be summarized as much as possible. First, short-run asymmetry is supported in the UK-Japan and the UK-Korea trade balance models. since ΔPOS and ΔNEG take different lags. Second, long-run asymmetry is supported in three models: the UK-Germany, the UK-Japan, and the UK-Italy trade balance models. In these models, our calculated Wald statistic ($Wald_{Long)}$ is highly significant, justifying long-run asymmetric effects of exchange rate changes. Third, the traditional definition of the J-curve (initial deterioration of the trade balance followed by an improvement, in the short-run) is supported only in the results for the UK-Korea model in Table 5 of Part I, since the ΔLnREX variable carries a negative coefficient initially, and then a significantly positive coefficient. Rose and Yellen's (1989) definition of the J-curve (short-run deterioration combined with long-run improvement) is not supported in any model. As for the third definition by Bahmani-Oskooee and Fariditavana (2015 and 2016), which is deterioration in the short-run combined with improvement in the long-run based on the partial sum concepts and POS and NEG

[11] Note that there are now four exogenous variables in the nonlinear model and the upper bound critical value at the 5% level is 4.01. (Pesaran *et al*. 2001, Table CI (iii) Case III, p. 300).

variables, the J-Curve is supported partially in the cases of the UK-Korea trade balance the (Table 5) and is fully supported in the case of the UK-US trade model (Table 8) in which the NEG variable carries a negative insignificant coefficient in the short-run but a significantly positive coefficient in the long-run. Thus, the new definition that is based on separating depreciations from appreciations yields more evidence of the J-Curve. Fourth, if our concern was only the long-run, we gather from the linear models that the UK's trade balance will improve only with Korea and the US, since the UK-Korea and the UK-US models (Table 5 and 8) since the real exchange rate carries a positive and significant coefficient in the long-run. However, using the nonlinear model, it is clear that the NEG variable carries a positive and significant coefficient in the UK-Korea and the UK-US models. Clearly, pound depreciation improves the UK's trade balance with its Korea and the US. These striking findings are absent from previous research, which relies only on the linear models. Finally, the nonlinear models are preferred since they also provide relatively more support for income effects in the case of the UK-Japan and the UK-Korea models as they have expected signs and statistically significant in most of the times. However, the coefficient is significantly positive in the cases of Canada, implying that as Canada grew, they most likely produced more import-substitute goods at home, and imported less from UK, as discussed in Bahmani-Oskooee (1986).

V. Conclusion

The impact of exchange rate movements on a country's trade balance is one of the major concerns for the researchers. Previously, it was considered that the exchange rate changes are related to trade balances linearly. However, the recent advances in time series econometrics have enabled the researchers to test the nonlinear impacts of exchange rate movements on trade balances. In this study, we tried to expand the existing literature the UK's bilateral trade with her 8 partners using the nonlinear ARDL approach to cointegration as well as the linear ARDL approach to cointegration.

It seems by and large that nonlinear ARDL econometric results are statistically more satisfying than the linear ARDL results. The nonlinear ARDL approach allows us separate the impacts of exchange rate changes in terms of appreciations and depreciations. The UK-Germany, the UK-Italy, and the UK-Japan trade balance models revealed the long-run asymmetric impacts of exchange rate changes whilst the short-run asymmetry was identified in the case of the UK-Korea model. The econometric results suggest that the British government should be aware of the consequences of asymmetric impacts of pound's appreciation and depreciation for each of her trading partner when the trade policies are formed so that international trade competitiveness does not suffer adversely.

Appendix

Data Definition and Sources

Monthly data over the period 1988M1-2015M11 are used, except Germany 1991M1-2015M1 and Italy 1997M1-2015M11 to estimate the econometric models.

They come from the following sources:

a. Direction of Trade Statistics by the IMF.
b. International Financials Statistics by the IMF

Variables

TB_i=British trade balance with partner i defined as the British imports from partner i over her exports to partner i. The data come from source a.

Y_{UK}=Measure of British income. It is proxied by seasonally adjusted index of industrial production. The data come from source b.

Y_i=Measure of trading partner i income. It is proxied by seasonally adjusted index of industrial production in country i. The data come from source b.

REX_i=The real bilateral exchange rate of British pound against the currency of partner i. It is defined as $REX_i=(P_{UK}NEX_i/P_i)$ where NEX_i is the nominal exchange rate defined as number of units of partner's i's currency per Bristish pound, P_{UK} is the price level in Britain (measured by CPI) and P_i is the price level in country in i (also measured by CPI). Thus, a decline in REX reflects a real depreciation of British pound. All nominal exchange rates and consumer price indexes data come from source b.

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Table 1. UK- Canada Models

Part I Full-Information Estimate of Linear ARDL Equation

Panel A: Short-run Coefficient Estimates

	Lag Order							
	0	1	2	3	4	5	6	7
Δln TB	-	-0.43 (5.27)*	-0.26 (3.37)*	-0.18 (2.34)**	-0.11 (2.52)**			
Δln Y_{UK}	-0.21 (0.55)							
Δln Y_{CA}	0.43 (3.83)*							
Δln REX	0.008 (0.01)	0.13 (0.29)	-0.68 (1.53)	0.53 (1.19)	-0.37 (0.83)	1.26 (2.79)*	0.80 (1.75)***	

Panel B: Long-run Coefficient Estimates

	Constant	Ln Y_{UK}	Ln Y_{CA}	Ln REX
	-1.49 (0.38)	-0.54 (0.56)	1.12 (6.88)*	-0.77 (1.75)**

Panel C: Diagnostic Statistics

	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	
	6.22**	-0.38 (4.85)*	22.73	2.97	S	S	0.41	

Part II Full-Information of Estimates of Nonlinear ARDL Equation

Panel D: Short-run Coefficient Estimates

	Lag Order							
	0	1	2	3	4	5	6	7
Δln TB	-	-0.40 (4.69)*	-0.22 (2.78)*	-0.16 (2.31)**	-0.10 (1.85)***			
Δln Y_{UK}	-1.21 (0.92)	-2.59 (1.97)**						
Δln Y_{CA}	0.16 (0.52)							
ΔPOS	-0.20 (1.40)							
ΔNEG	0.28 (1.68)***							

Panel E: Long-run Coefficient Estimates

	Constant	Ln Y_{UK}	Ln Y_{CA}	POS	NEG
	0.39 (0.11)	-0.43 (0.44)	0.37 (0.52)	-0.49 (1.42)	-0.67 (1.75)***

Panel F: Diagnostic Statistics

	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	W_{Short}	W_{Long}
	5.17**	-0.42 (5.07)*	20.9	2.27	UNS	S	0.39	0.18	1.25

Notes: a. The number inside the parentheses are absolute t-ratios . *, ** and *** indicate, 1%, 5% and 10% significance levels, respectively.
b. LM is the Lagrange multiplier test for serial correlation. It has a χ^2 distribution with four degrees of freedom. The critical value at the 5% level of significance is 9.48.
c. RESET is Ramsey's specification test. It has a χ^2 distribution with one degree of freedom. The critical value at the 5% level of significance is 3.84.
d. CUSM and $CUSM^2$ stand for cumulative sums of recursive residuals and cumulative sums of squared recursive residuals' tests, respectively. S and UNS indicate stability and unstability, respectively.
e. W_{Short} and W_{Long} represent the Wald test for short-run and long-run of asymmetry or symmetry, respectively. This test has a χ^2 distribution with one degree of freedom.

Table 2. UK- Germany Models

Part I Full-Information Estimate of Linear ARDL Equation

Panel A: Short-run Coefficient Estimates

	Lag Order							
	0	1	2	3	4	5	6	7
Δln TB	-	-0.32 (4.57)*	-0.15 (2.19)**	-0.09 (1.53)				
Δln Y_{UK}	-0.18 (1.60)***							
Δln Y_{DE}	0.94 (2.92)*							
Δln REX	0.02 (0.38)							

Panel B: Long-run Coefficient Estimates

	Constant	Ln Y_{UK}	Ln Y_{DE}	Ln REX	
	-0.13 (0.04)	-0.80 (1.56)	0.96 (5.51)*	-0.09 (0.39)	

Panel C: Diagnostic Statistics

	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	
	4.80**	-0.22 (4.15)*	37.15	0.01	S	S	0.24	

Part II Full-Information of Estimates of Nonlinear ARDL Equation

Panel D: Short-run Coefficient Estimates

	Lag Order							
	0	1	2	3	4	5	6	7
Δln TB	-	-0.30 (4.20)*	-0.13 (2.00)**	-0.08 (1.40)				
Δln Y_{UK}	-0.15 (1.33)							
Δln Y_{DE}	0.83 (2.56)*							
ΔPOS	-0.009 (0.15)							
ΔNEG	-0.03 (0.54)							

Panel E: Long-run Coefficient Estimates

	Constant	Ln Y_{UK}	Ln Y_{DE}	POS	NEG	
	1.55 (0.59)	-0.57 (1.30)	0.29 (0.80)	0.03 (0.15)	-0.11 (0.56)	

Panel F: Diagnostic Statistics

	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	W_{Short}	W_{Long}
	4.67**	-0.27 (4.59)*	40.8	0.007	S	S	0.25	0.19	6.49**

Notes: a. The number inside the parentheses are absolute t-ratios . *, ** and *** indicate, 1%, 5% and 10% significance levels, respectively.
b. LM is the Lagrange multiplier test for serial correlation. It has a χ^2 distribution with four degrees of freedom. The critical value at the 5% level of significance is 9.48.
c. RESET is Ramsey's specification test. It has a χ^2 distribution with one degree of freedom. The critical value at the 5% level of significance is 3.84.
d. CUSM and $CUSM^2$ stand for cumulative sums of recursive residuals and cumulative sums of squared recursive residuals' tests, respectively. S and UNS indicate stability and unstability, respectively.
e. W_{Short} and W_{Long} represent the Wald test for short-run and long-run of asymmetry or symmetry, respectively. This test has a χ^2 distribution with one degree of freedom.

Table 3. UK- Italy Models

Part I Full-Information Estimate of Linear ARDL Equation

Panel A: Short-run Coefficient Estimates

	Lag Order							
	0	1	2	3	4	5	6	7
Δln TB	-	-0.53 $(7.84)^{*}$	-0.30 $(4.23)^{*}$	-0.17 $(2.36)^{**}$	-0.09 (1.27)	-0.14 $(2.07)^{**}$	-0.17 $(2.77)^{*}$	-0.13 $(2.45)^{**}$
Δln Y_{UK}	0.41 (1.03)							
Δln Y_{IT}	-0.33 (1.36)							
Δln REX	0.36 (0.94)	-0.45 (1.19)	0.35 (0.91)	0.89 $(2.36)^{**}$	0.55 (1.47)	-0.79 $(2.08)^{**}$	-0.46 (1.21)	-0.77 $(2.00)^{**}$

Panel B: Long-run Coefficient Estimates

	Constant	Ln Y_{UK}	Ln Y_{IT}	Ln REX
	-0.68 (0.09)	3.91 (1.08)	-3.15 (1.49)	-0.31 (0.26)

Panel C: Diagnostic Statistics

	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	
	0.95	-0.38 $(4.85)^{*}$	118.4	0.94	S	UNS	0.30	

Part II Full-Information of Estimates of Nonlinear ARDL Equation

Panel D: Short-run Coefficient Estimates

	Lag Order							
	0	1	2	3	4	5	6	7
Δln TB	-	-0.32 $(5.06)^{*}$	-0.12 $(2.29)^{**}$					
Δln Y_{UK}	-0.27 (0.64)							
Δln Y_{IT}	0.10 (0.43)							
ΔPOS	-0.10 (0.16)	-0.52 (0.79)	0.46 (0.69)	1.38 $(2.10)^{**}$	0.84 (1.26)	1.58 $(2.39)^{**}$	1.39 $(2.08)^{**}$	1.42 $(2.13)^{**}$
ΔNEG	-0.01 (0.10)							

Panel E: Long-run Coefficient Estimates

	Constant	Ln Y_{UK}	Ln Y_{IT}	POS	NEG
	5.08 $(1.65)^{***}$	-0.77 (0.64)	0.30 (0.43)	0.17 (0.56)	-0.03 (0.10)

Panel F: Diagnostic Statistics

	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	W_{Short}	W_{Long}
	7.62^{**}	-0.35 $(6.08)^{*}$	116	0.96	UNS	S	0.31	0.85	21.49^{*}

Notes: a. The number inside the parentheses are absolute t-ratios . *, ** and *** indicate, 1%, 5% and 10% significance levels, respectively.
b. LM is the Lagrange multiplier test for serial correlation. It has a χ^2 distribution with four degrees of freedom. The critical value at the 5% level of significance is 9.48.
c. RESET is Ramsey's specification test. It has a χ^2 distribution with one degree of freedom. The critical value at the 5% level of significance is 3.84.
d. CUSM and $CUSM^2$ stand for cumulative sums of recursive residuals and cumulative sums of squared recursive residuals' tests, respectively. S and UNS indicate stability and unstability, respectively.
e. W_{Short} and W_{Long} represent the Wald test for short-run and long-run of asymmetry or symmetry, respectively. This test has a χ^2 distribution with one degree of freedom.

Table 4. UK- Japan Models									
Part I Full-Information Estimate of Linear ARDL Equation									
Panel A: Short-run Coefficient Estimates									
	Lag Order								
	0	1	2	3	4	5	6	7	
Δln TB	-	-0.61 (9.20)*	-0.49 (6.78)*	-0.28 (3.74)*	-0.26 (3.51)*	-0.15 (2.32)**	-0.11 (1.97)**		
Δln Y_{UK}	-1.20 (1.31)								
Δln Y_{JP}	0.04 (0.25)								
Δln REX	-0.37 (1.41)	0.13 (0.50)	-0.20 (0.74)	-0.43 (1.59)	-0.39 (1.43)	0.92 (3.34)*	-0.59 (2.18)**		
Panel B: Long-run Coefficient Estimates									
	Constant	Ln Y_{UK}	Ln Y_{JP}	Ln REX					
	-9.30 (0.73)	1.23 (0.47)	0.63 (0.25)	-0.27 (0.27)					
Panel C: Diagnostic Statistics									
	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2		
	0.97	-0.06 (1.56)	38.6	0.19	S	S	0.36		
Part II Full-Information of Estimates of Nonlinear ARDL Equation									
Panel D: Short-run Coefficient Estimates									
	Lag Order								
	0	1	2	3	4	5	6	7	
Δln TB	-	-0.37 (4.92)*	-0.31 (4.25)*	-0.10 (1.48)	-0.10 (1.93)***				
Δln Y_{UK}	-0.62 (0.67)	1.28 (1.39)							
Δln Y_{JP}	-0.13 (0.79)								
ΔPOS	-0.01 (0.26)								
ΔNEG	-0.94 (2.38)**	0.40 (0.95)	-0.67 (1.57)	-0.26 (0.62)	-0.98 (2.29)**	1.16 (2.70)*	-0.99 (2.43)**		
Panel E: Long-run Coefficient Estimates									
	Constant	Ln Y_{UK}	Ln Y_{JP}	POS	NEG				
	1.18 (0.45)	0.92 (1.85)***	-0.43 (0.79)	0.04 (0.26)	0.22 (1.14)				
Panel F: Diagnostic Statistics									
	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	W_{Short}	W_{Long}
	4.89**	-0.32 (4.73)*	29.4	0.49	S	S	0.38	4.69**	17.76*

Notes: a. The number inside the parentheses are absolute t-ratios . *, ** and *** indicate, 1%, 5% and 10% significance levels, respectively.
b. LM is the Lagrange multiplier test for serial correlation. It has a χ^2 distribution with four degrees of freedom. The critical value at the 5% level of significance is 9.48.
c. RESET is Ramsey's specification test. It has a χ^2 distribution with one degree of freedom. The critical value at the 5% level of significance is 3.84.
d. CUSM and $CUSM^2$ stand for cumulative sums of recursive residuals and cumulative sums of squared recursive residuals' tests, respectively. S and UNS indicate stability and unstability, respectively.
e. W_{Short} and W_{Long} represent the Wald test for short-run and long-run of asymmetry or symmetry, respectively. This test has a χ^2 distribution with one degree of freedom.

Table 5. UK- Korea Models

Part I Full-Information Estimate of Linear ARDL Equation

Panel A: Short-run Coefficient Estimates

	Lag Order							
	0	1	2	3	4	5	6	7
Δln TB	-	-0.37 (5.06)*	-0.12 (1.63)***	-0.06 (0.92)	0.08 (1.51)			
Δln Y_{UK}	-1.54 (0.87)							
Δln Y_{KR}	-0.17 (4.54)*							
Δln REX	0.46 (1.06)	0.18 (0.40)	0.37 (0.82)	-1.23 (2.77)*				

Panel B: Long-run Coefficient Estimates

	Constant	Ln Y_{UK}	Ln Y_{KR}	Ln REX
	-28.95 (9.32)*	4.45 (6.50)*	-0.43 (6.71)*	1.38 (4.30)*

Panel C: Diagnostic Statistics

	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	
	8.96**	-0.41 (6.03)*	27.57	0.73	S	UNS	0.41	

Part II Full-Information of Estimates of Nonlinear ARDL Equation

Panel D: Short-run Coefficient Estimates

	Lag Order							
	0	1	2	3	4	5	6	7
Δln TB	-	-0.34 (4.65)*	-0.09 (1.35)	-0.04 (0.66)	-0.09 (1.73)***			
Δln Y_{UK}	-1.40 (0.87)							
Δln Y_{KR}	-0.06 (0.29)							
ΔPOS	0.54 (3.81)*							
ΔNEG	0.82 (0.96)	-0.17 (0.20)	0.21 (0.24)	-2.49 (2.89)*	1.34 (1.58)			

Panel E: Long-run Coefficient Estimates

	Constant	Ln Y_{UK}	Ln Y_{KR}	POS	NEG
	-19.99 (6.85)*	4.59 (6.71)*	-0.14 (0.29)	1.17 (4.18)*	1.29 (3.35)*

Panel F: Diagnostic Statistics

	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	W_{Short}	W_{Long}
	8.88**	-0.46 (6.58)*	27.7	0.01	S	UNS	0.42	3.40**	1.48

Notes: a. The number inside the parentheses are absolute t-ratios . *, ** and *** indicate, 1%, 5% and 10% significance levels, respectively.
b. LM is the Lagrange multiplier test for serial correlation. It has a χ^2 distribution with four degrees of freedom. The critical value at the 5% level of significance is 9.48.
c. RESET is Ramsey's specification test. It has a χ^2 distribution with one degree of freedom. The critical value at the 5% level of significance is 3.84.
d. CUSM and $CUSM^2$ stand for cumulative sums of recursive residuals and cumulative sums of squared recursive residuals' tests, respectively. S and UNS indicate stability and unstability, respectively.
e. W_{Short} and W_{Long} represent the Wald test for short-run and long-run of asymmetry or symmetry, respectively. This test has a χ^2 distribution with one degree of freedom.

Table 6. UK- Norway Models								
Part I Full-Information Estimate of Linear ARDL Equation								
Panel A: Short-run Coefficient Estimates								
	Lag Order							
	0	1	2	3	4	5	6	7
Δln TB	-	-0.56 (9.42)*	-0.39 (5.99)*	-0.24 (3.87)**	-0.14 (2.55)***			
Δln Y_{UK}	0.33 (0.72)							
Δln Y_{NO}	-0.02 (0.10)							
Δln REX	-1.06 (1.83)**							
Panel B: Long-run Coefficient Estimates								
	Constant	Ln Y_{UK}	Ln Y_{NO}	Ln REX				
	-20.84 (0.61)	6.85 (0.63)	-0.41 (0.10)	-3.16 (1.01)				
Panel C: Diagnostic Statistics								
	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	
	1.23	-0.04 (1.62)***	20.19	0.006	S	S	0.26	
Part II Full-Information of Estimates of Nonlinear ARDL Equation								
Panel D: Short-run Coefficient Estimates								
	Lag Order							
	0	1	2	3	4	5	6	7
Δln TB	-	-0.48 (7.42)*	-0.32 (4.79)*	-0.19 (2.96)*	-0.11 (2.08)**			
Δln Y_{UK}	-1.14 (0.79)	-3.35 (2.23)**	-2.54 (1.76)***					
Δln Y_{NO}	0.16 (0.52)							
ΔPOS	0.05 (1.53)							
ΔNEG	-2.28 (2.34)**							
Panel E: Long-run Coefficient Estimates								
	Constant	Ln Y_{UK}	Ln Y_{NO}	POS	NEG			
	-22.51 (2.06)**	8.83 (2.51)**	-3.84 (2.52)**	-1.61 (1.67)***	-2.11 (2.24)**			

Panel F: Diagnostic Statistics									
	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	W_{Short}	W_{Long}
	3.15	-0.16 (5.07)*	19.5	2.20	S	S	0.29	1.71	6.90*

Notes: a. The number inside the parentheses are absolute t-ratios . *, ** and *** indicate, 1%, 5% and 10% significance levels, respectively.
b. LM is the Lagrange multiplier test for serial correlation. It has a χ^2 distribution with four degrees of freedom. The critical value at the 5% level of significance is 9.48.
c. RESET is Ramsey's specification test. It has a χ^2 distribution with one degree of freedom. The critical value at the 5% level of significance is 3.84.
d. CUSM and $CUSM^2$ stand for cumulative sums of recursive residuals and cumulative sums of squared recursive residuals' tests, respectively. S and UNS indicate stability and unstability, respectively.
e. W_{Short} and W_{Long} represent the Wald test for short-run and long-run of asymmetry or symmetry, respectively. This test has a χ^2 distribution with one degree of freedom.

Table 7. UK- Spain Models

Part I Full-Information Estimate of Linear ARDL Equation

Panel A: Short-run Coefficient Estimates

	Lag Order							
	0	1	2	3	4	5	6	7
Δln TB	-	-0.68 (10.6)*	-0.49 (6.86)*	-0.39 (5.49)*	-0.43 (6.13)**	-0.24 (3.60)*	-0.09 (1.68)***	
Δln Y_{UK}	-0.004 (0.13)							
Δln Y_{SP}	0.05 (0.40)							
Δln REX	0.63 (1.58)							

Panel B: Long-run Coefficient Estimates

	Constant	Ln Y_{UK}	Ln Y_{SP}	Ln REX
	3.71 (0.13)	-0.15 (0.01)	1.78 (0.41)	-2.05 (0.57)

Panel C: Diagnostic Statistics

	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	
	0.36	-0.03 (0.86)	119.17	3.38	S	UNS	0.34	

Part II Full-Information of Estimates of Nonlinear ARDL Equation

Panel D: Short-run Coefficient Estimates

	Lag Order							
	0	1	2	3	4	5	6	7
Δln TB	-	-0.49 (6.34)*	-0.35 (4.42)*	-0.30 (4.00)*	-0.35 (4.98)*	-0.19 (2.90)*	-0.07 (1.43)	
Δln Y_{UK}	-0.24 (0.68)							
Δln Y_{SP}	0.10 (0.76)							
ΔPOS	0.15 (1.49)							
ΔNEG	0.06 (0.68)							

Panel E: Long-run Coefficient Estimates

	Constant	Ln Y_{UK}	Ln Y_{SP}	POS	NEG
	6.01 (1.32)	-0.98 (0.71)	-0.42 (0.75)	0.61 (1.57)	0.25 (0.68)

Panel F: Diagnostic Statistics

	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	W_{Short}	W_{Long}
	2.67	-0.24 (3.57)*	116	0.01	UNS	UNS	0.39	0.30	12.31*

Notes: a. The number inside the parentheses are absolute t-ratios . *, ** and *** indicate, 1%, 5% and 10% significance levels, respectively.
b. LM is the Lagrange multiplier test for serial correlation. It has a χ^2 distribution with four degrees of freedom. The critical value at the 5% level of significance is 9.48.
c. RESET is Ramsey's specification test. It has a χ^2 distribution with one degree of freedom. The critical value at the 5% level of significance is 3.84.
d. CUSM and $CUSM^2$ stand for cumulative sums of recursive residuals and cumulative sums of squared recursive residuals' tests, respectively. S and UNS indicate stability and unstability, respectively.
e. W_{Short} and W_{Long} represent the Wald test for short-run and long-run of asymmetry or symmetry, respectively. This test has a χ^2 distribution with one degree of freedom.

Table 8. UK- US Models

Part I Full-Information Estimate of Linear ARDL Equation

Panel A: Short-run Coefficient Estimates

	Lag Order							
	0	1	2	3	4	5	6	7
$\Delta \ln TB$	-	-0.42 (5.19)*	-0.13 (1.65)***	-0.02 (0.37)	-0.05 (0.69)	-0.05 (0.72)	-0.19 (2.89)*	-0.10 (1.79)***
$\Delta \ln Y_{UK}$	0.18 (1.24)							
$\Delta \ln Y_{US}$	-0.19 (3.14)*							
$\Delta \ln REX$	0.16 (2.12)**							

Panel B: Long-run Coefficient Estimates

	Constant	$\ln Y_{UK}$	$\ln Y_{US}$	$\ln REX$	
	0.18 (0.21)	0.56 (1.33)	-0.61 (4.62)*	0.50 (2.52)**	

Panel C: Diagnostic Statistics

	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	
	4.19***	-0.32 (4.18)*	34.23	0.34	S	S	0.36	

Part II Full-Information of Estimates of Nonlinear ARDL Equation

Panel D: Short-run Coefficient Estimates

	Lag Order							
	0	1	2	3	4	5	6	7
$\Delta \ln TB$	-	-0.30 (4.20)*	-0.13 (2.00)**	-0.08 (1.40)				
$\Delta \ln Y_{UK}$	-0.15 (1.33)							
$\Delta \ln Y_{US}$	0.83 (2.56)*							
ΔPOS	-0.009 (0.15)							
ΔNEG	-0.03 (0.54)							

Panel E: Long-run Coefficient Estimates

	Constant	$\ln Y_{UK}$	$\ln Y_{US}$	POS	NEG	
	1.89 (1.01)	-0.55 (0.67)	0.19 (0.34)	0.44 (2.51)**	0.60 (2.90)*	

Panel F: Diagnostic Statistics

	F	ECM_{t-1}	LM	RESET	CUSM	$CUSM^2$	Adj.R^2	W_{Short}	W_{Long}
	7.06**	-0.40 (6.01)*	56.1	0.82	S	S	0.38	0.00004	1.10

Notes: a. The number inside the parentheses are absolute t-ratios . *, ** and *** indicate, 1%, 5% and 10% significance levels, respectively.
b. LM is the Lagrange multiplier test for serial correlation. It has a χ^2 distribution with four degrees of freedom. The critical value at the 5% level of significance is 9.48.
c. RESET is Ramsey's specification test. It has a χ^2 distribution with one degree of freedom. The critical value at the 5% level of significance is 3.84.
d. CUSM and $CUSM^2$ stand for cumulative sums of recursive residuals and cumulative sums of squared recursive residuals' tests, respectively. S and UNS indicate stability and unstability, respectively.
e. W_{Short} and W_{Long} represent the Wald test for short-run and long-run of asymmetry or symmetry, respectively. This test has a χ^2 distribution with one degree of freedom.